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)evelopment and performance evaluation of a manual fruit harvester

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Abstract: **The conventional methods used for harvesting fruits are crude, laborious and time consuming. The fruit harvesting systems employing vibratory mechanism and mechanical harvesting prevalent in the advanced countries cannot be adopted in Indian conditions. With a view of simplifying the fruit harvesting operation, a manual fruit harvester was developed and tested. Three types of blade *viz.* curved blade, V-shaped blade and scissor type blade were fabricated and attached with the harvester. The field capacity and good fruit percentage by the three blades were determined for five important fruit crops. The combination of V-shaped harvester for pomegranate fruit gave maximum field capacity. The good fruit percentage was found to be more in lime. Guava was subjected to maximum damage due to its soft and smooth skin.**

Key words : Fruit harvester.

ıtroduction

India has varied climatic zones and almost il types of fruits are grown. The fruit production n India was 40.05 million tonnes (mango 10.50, ɔanana 10.32, citrus 4.26, apple 1.32, pineapple).95, papaya 1.58, sapota 0.63, litchi 0.45 and ;rapes 0.97 t) during 1997-98 and ranked as ıumber two in world after China (Mandhar, 2000). The major tropical and subtropical fruits grown ıre mango, banana, citrus and guava and the najor temperate fruit grown is apple. The other ruits of economic importance are grapes, ɔomegranate, litchi and pine apple.

Fruits form a considerable part of human consumption. As it is a major food item, the damages occurring to fruits during harvesting should be avoided. Harvesting of fruits need adjustments with nature of fruits, stage of maturity and ripening, the purpose for which it is required and the distance it has to transverse before consumption. Fruits may be harvested at fully ripened stage, if they are needed for spot consumption. All fruits cannot be harvested at fully ripened stage. Damaged fruits lead to post harvesting losses. Some fruits give the indication of full maturity only when the tree-ripe fruits fall to the ground while others may do so by colour changes.

In general, harvesting aids result in only moderate or small increase in productivity and they sometimes represent substantial investments. When several workers use the same equipment, the rate of output for the entire operation is usually limited by the slowest. Machines for individual workers may give greater average outputs but are more costly. Many fruit crops do not mature uniformly. Several pickings are required to obtain maximum yields, selecting only the mature products each time. If such a crop is to be harvested mechanically, some characteristic that is related to maturity and identifiable by a machine must be found. Selectivity in hand harvesting is often based upon visual evaluation of size, colour and shape or an intuitive integration of these factors. With most crops it is different to achieve machine selectivity comparable with hand selectivity. The ideal situation for mechanical harvesting is to have all or most of the crop ready to harvest at one time. Minimizing damage to easily bruised fruits is an important consideration in designing a harvester and the associated handling equipment.

Mc Birney (1967) made a highest adjustable picking platform machine. The machine was the adoption of a self-propelled machine with adjustable height platform for picking. A fork lift attachment was added for lifting the cabin a few inches off the ground and carrying it along. A bucket with quick emptying bottom was mounted on the frame work of the picker platform to reduce the frequency of emptying. Such adoptions increased the extensive use of the machine.

Roy and Smith (1963) reported a latest aid to harvest the fruits, which is a three wheeled vehicle. The essential part of which is a moving

Table 1. Performance of fruit harvesters

Fruit	Field capacity, kg hr^{-1}															
	Curved blade				V-shaped blade				Scissor type blade				Manual harvesting			
	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4
Mango	18.5	18.1	17.9	18.7	21.1	20.7	20.2	19.1	18.3	18.3	19.0	18.0	17.3	16.6	17.1	16.4
Guava	21.6	20.1	19.8	20.1	22.1	21.7	20.9	21.2	18.7	19.6	19.2	19.9	18.6	17.9	18.9	18.3
Sapota	17.3	17.8	18.1	18.0	19.6	18.3	17.9	19.9	16.1	16.6	16.0	15.9	16.3	16.3	15.9	15.2
Pomegranate	21.9	21.6	20.9	21.5	25.2	23.9	22.1	24.7	24.7	22.0	0.2	19.7	19.2	19.6	19.9	20.8
Lime	13.9	13.6	12.8	13.1	15.6	15.2	16.0	13.9	14.5	14.6	41.1	14.2	12.7	12.9	13.6	13.1
	Good fruit percentage															
Fruit	Curved blade				V-shaped blade				Scissor type blade				Manual harvesting			
	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4	R_1	R_2	R_3	R_4
Mango	87.3	88.6	79.9	87.2	90.2	90.1	83.6	85.4	85.0	81.0	79.6	82.1	60.7	61.6	63.5	60.1
Guava	78.9	79.1	80.1	81.2	90.3	90.6	79.7	89.8	83.1	86.5	78.5	79.3	53.2	56.1	59.5	38.0
Sapota	83.6	87.5	82.1	80.6	90.6	91.7	96.3	92.1	86.5	89.2	85.3	86.1	60.7	69.7	72.1	63.0
Pomegranate	96.1	89.2	87.5	88.1	98.2	91.6	97.5	91.2	90.6	80.3	78.6	79.2	71.6	70.2	18.3	70.3
Lime	93.5	96.1	88.7	83.6	96.3	92.8	99.0	99.6	92.1	97.0	90.2	89.1	89.2	86.3	90.1	90.2

chassis supporting a boom and hoist. The vehicle travels straight down each row, guided by a pair of discs fitted ahead of front wheel. Preliminary tests have shown that the amount of fruits which can be picked by the machine with single operator can substantially exceed that picked in the same time by the conventional ladder, bag and yield box method. Except while adjusting his position, the operator has both hands free for picking. He snips the fruit off the tree and drops it into a funnel between his legs. From there the fruit will be moved automatically to a bin on the platform.

Monroe and Levin (1967) made an investigation to develop a continuous blue berry harvester which would move down rows of blue berries at a speed of 0.8 kmh^{-1} and requires only a driver and other two workers. Mehischan and Canaverta (1977) developed a method to harvest Valencia oranges selectively. Flexible curved "fingers" of predetermined curvature and stiffness were used as picking elements. The picking unit was supported by a positioning mechanism on a self propelled carrier.

Sunner and Hedden (1982) introduced a hydraulic cutter for harvesting tree fruits especially for pineapple and banana. This could be operated by hand pump or by gear pump driven by portable engine. The cutting blade operated by the ram were connected to one end of a long extendible aluminium pole and the pump was attached to other end. The total weight of the cutter was 6 kg with hand pump and 12 kg with engine driven pump attached.

Taking into consideration of all the above facts and the mechanization level in our country, it is not desirable to develop a mechanical fruit harvester. It is the best to develop a simple manual fruit harvester and hence opted for the choice of developing a manual fruit harvester with following objectives.

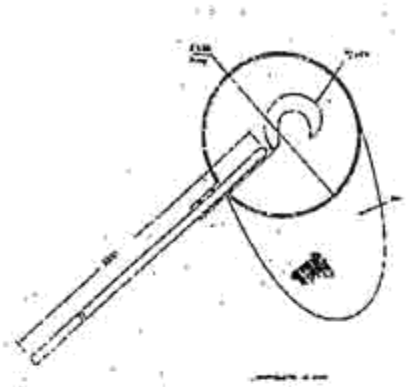

Fig.1 Curved Blade

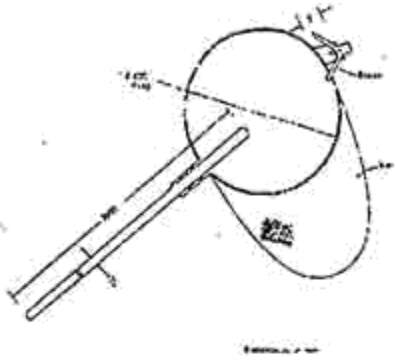

Fig.2 V-Type Blade

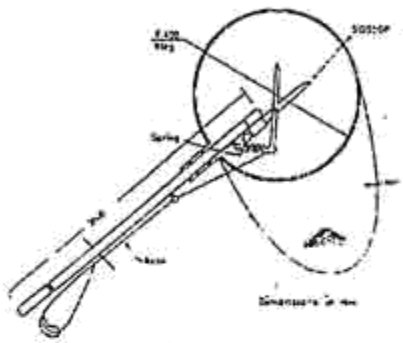

Fig.3 Scissor Type

Minimization of damages to fruits while harvesting.
Minimization of labour cost
Minimization of drudgery of labour.

aterials and Methods

scription of the prototype developed

The prototype developed was a manually perated one which consisted of a blade, an luminium pipe and a circular ring with net.

lade

It refered to the cutting portion of the larvester. It is to be very sharp for easy fruit emoval. Blades were of various types depending pon the shape.

1) Curved blade (Fig.1)
2) V-shaped blade (Fig.2)
3) Scissor type blade (Fig.3)

i) Curved blade

Curved blade was further classified based n the included angle provided for cutting.

) Curved blade with included angle of 120°.
) Curved blade with included angle of 150°.

The above two blades have a curvilinear urface and they are grinded sharply along the utting edge. The cutting edge removed the fruit rom its stem. The blades were normally provided vith the following dimensions.

S. No.	Particulars	Head portion (mm)	Internal portion (mm)	End portion (mm)
1.	Curve with included angle of 120°	70	30	50
2.	Curved blade with included angle of 150°	70	50	50

ii) V-shaped blade

V-shaped blade consisted of a central vertical portion, at the top of which lie the V-shaped cutting portion on either side. The cutting edges were sharpened for easy fruit detachment. They were at an angle of 45° to the vertical portion. The blades were provided with the following dimensions.

Central fixed portion - 100 mm
Side cutting portion on either side - 100 mm

iii) Scissor type blade

Scissor type blade consisted of a pair of arms which were hinged at a central point providing sufficient space for cutting edge and handling portion. The cutting edges were sharpened along with opposite sides for perfect cutting. The dimensions of cutting arm and handle were 200 mm and 120 mm respectively.

2. *Aluminium pipe*

The length of the aluminimum pipe ranged between 3000 to 3600 mm. The highest was such that the fruits spread over the entire canopy of the tree can be harvested without any difficulty. The aluminium pipe is of less weight compared to other holding means like bamboo, etc. At the end of the pipe, a circular ring was attached for collecting the fruit. It was of light weight so that plucking of fruits was easier. The diameter and the length of the pipe were 25 mm and 3000 mm respectively.

3. *Circular ring with net*

The circular ring was attached at the end of the aluminium pipe. It was made of 6 mm diameter mild steel rod. Its perimeter was about 1750 mm. A mild steel rod was bent into circular shape and the two ends of the bent ring were flattened for fixing it with the aluminium pipe. The blades were fixed at the top most position of the circular ring. A net was wound around the circular ring to collect harvested fruits.

Principles of harvester developed

The fruit harvester developed works on the principle of manual harvesting. The force was transferred to the blade manually through the aluminium pipe. A single labour is sufficient for harvesting the fruits. An aluminium pipe of length 3000 mm facilitated the plucking of fruits spread over the entire canopy of the tree. As the fruits could be easily visualised, ripened fruits alone can be picked which increased the efficiency of operation.

Field evaluation

The fruit harvester developed was field evaluated at TNAU orchard. Three types of blades *viz.* curved blade, V-shaped blade and scissor type blade were attached with the harvester. The plucking of fruits was carried out individually and the field capacity and the damage were measured simultaneously for the above three types of blades (Table 1).

Statistical analysis

Based on the observations of the performance of the three blades in terms of field capacity and good fruit percentage, the factorial randomized block design (FRBD) was tried to know the suitability of blade. These three blades were compared with the manual picking also.

Results and Discussion

The field capacity and good fruit percentage for the various fruit harvesters were estimated for five important fruit crops of South India. (Table 1). The fruit trees selected for evaluating the harvester performance were mango, guava, sapota, pomegranate and lime. Among the various type of harvesters tested for field capacity, the V-shaped fruit harvester was found to be the best one. However the field capacity of all the three fruit harvesters were more than that of manual picking. Among the fruits, pomegranate gave more field capacity for the various harvesters tried whereas lime has yielded poor performance. Hence a combination of V-shaped harvester and for pomegranate fruits gave maximum field capacity.

In the case of good fruit percentage also the V-shaped harvester dominated over the other harvesters tested. The good fruit percentage was found to be more in lime. This may be due to the reason that the lime is covered by a hard skin, compared to other fruits harvested. Guava was subjected to maximum damage due to its soften and smooth skin.

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